Particle-Based Labeling: Fast Point-Feature Labeling without Obscuring Other Visual Features

Martin Luboschik, Heidrun Schumann, Hilko Cords
Computer Graphics & Visualization Group
University of Rostock, Germany
Motivation

- Labeling needs in Visualization:
  - Real-time interaction
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For legibility reasons!
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For reasons!
Visualization For visualization reasons!
For reasons!
Visualization For reasons!
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Labeling needs in Visualization:

- Real-time interaction
- No preprocessing
- No label – label conflicts
- No label – visual object conflicts
- No constraints (e.g., label size)
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more important
not important
very important

more important
not important
very important
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  • Global labeling solution
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Related Work

“The Map-Labeling Bibliography”

By Alexander Wolf and Tycho Strijk
Particle-based labeling

Outline

- Labeling Pipeline
- Particle-based conflict detection
- Regarding visual objects
- Labeling arbitrarily shaped objects
- Placing arbitrarily shaped labels
Particle-based labeling

The labeling pipeline

Labeling with the 4-position model
Particle-based labeling

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Labeling with the 4-position model

2

1
Particle-based labeling

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Particle-based labeling

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Labeling with the 4-position model

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td>4</td>
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7 6 5
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- Labeling with distant label positions
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Labeling with distant label positions

complexity
processed features
Particle-based labeling

Particle-based conflict detection

- Label position is accepted if no conflict particle is inside:

```
Conflict particles

\[
 \begin{align*}
 &\quad \text{Label particles represent point-features} \\
 &\quad \text{Virtual particles represent occupied space}
\end{align*}
\]
```
Particle-based labeling

Particle-based conflict detection

- Label position is accepted if no conflict particle is inside:

<table>
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<th>Label particles represent point-features</th>
</tr>
</thead>
<tbody>
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<td></td>
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Diagram showing particle positions.
**Particle-based labeling**

**Particle-based conflict detection**

- Label position is accepted if **no** conflict particle is inside:

  **Conflict particles**

  - Label particles represent point-features
  - Virtual particles represent occupied space

![Diagram showing label position and conflict detection with coordinates](image-url)
Particle-based labeling

Particle-based conflict detection

- Prevent occlusion by generating new virtual particles:
Particle-based labeling

Particle-based conflict detection

- Prevent occlusion by generating new virtual particles:
Particle-based labeling

Particle-based conflict detection

• Prevent occlusion by generating new virtual particles:

• Local neighborhood data structure (grid):

\[
\begin{align*}
lh_{\text{min}} & \quad lh_{\text{max}} \\
lw_{\text{min}} & \quad lw_{\text{max}}
\end{align*}
\]
Particle-based labeling

Particle-based conflict detection

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Particle-based labeling

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Summary:
Summary:

- All point-features are processed within one pipeline-step before passing the left unlabeled ones to the next pipeline-step !!!
Particle-based labeling

Regarding other visual objects

• How to obtain the occupied space of other visual objects?
Particle-based labeling

Regarding other visual objects

- Image-based approach:
Particle-based labeling

Regarding other visual objects

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Particle-based labeling
Regarding other visual objects

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Regarding other visual objects

• Vector-based approach:
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Regarding other visual objects

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Labeling arbitrarily shaped objects

- Image-based approach:

Icons: www.sp-studio.de
Particle-based labeling

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Placing arbitrarily shaped labels
Particle-based labeling
Placing arbitrarily shaped labels

[Diagram showing arbitrarily shaped labels]
Perfomance

• As fast as fastest non-preprocessing methods

• Benchmarks:
  • 750 point features within 4 ms
  • 1,000 point features within 10 ms

• Stress test:
  • 100,000 point features within 0.7 s
  • 200,000 point features within 1.2 s

Configuration:
Dual-core desktop PC:
2.6 GHz AMD 64 CPU
2 GB RAM
GeForce 8800 GTX
Implementation:
ANSI-C, single-core, non-GPU
Majority of labels are adjacent labels

Distant labels lead to superior number of placed labels
Demo / Video

Visit

http://www.informatik.uni-rostock.de/~malub/pub/08/labeling/info.html

for a video!
Results

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  - No constraints (e.g., label size)
  - Global labeling solution
Results

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  • Global labeling solution
  • No clutter
Outlook

- Reduction of
  - Popping labels
  - Distant labels

- Successive refinements

- Embedding further cartographic knowledge
Thank you!